# TREE-RING PERSPECTIVE ON COLORADO RIVER BASIN DROUGHT

*Presentation for the California Department of Water Resources*
*Salton Sea Advisory Committee Meeting*

*Sacramento, California, 8 June 2004*

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**Laboratory of Tree-Ring Research**
**University of Arizona**

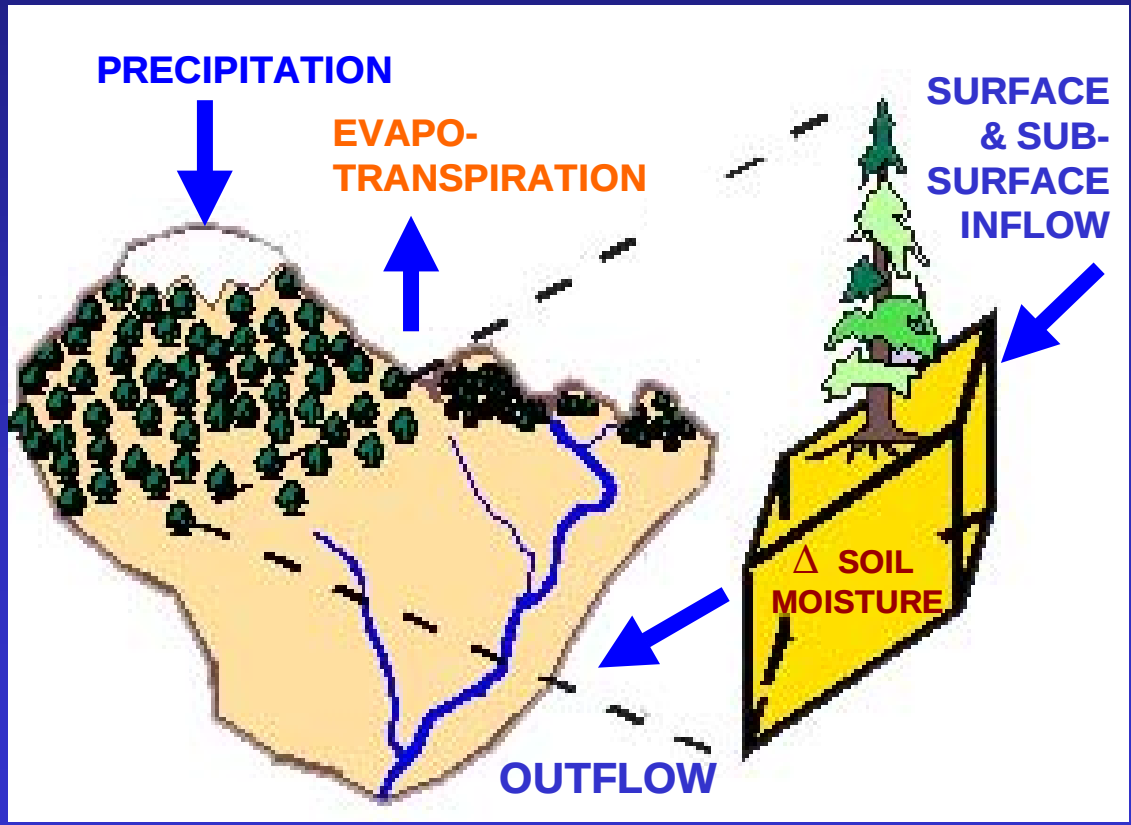
# OVERVIEW

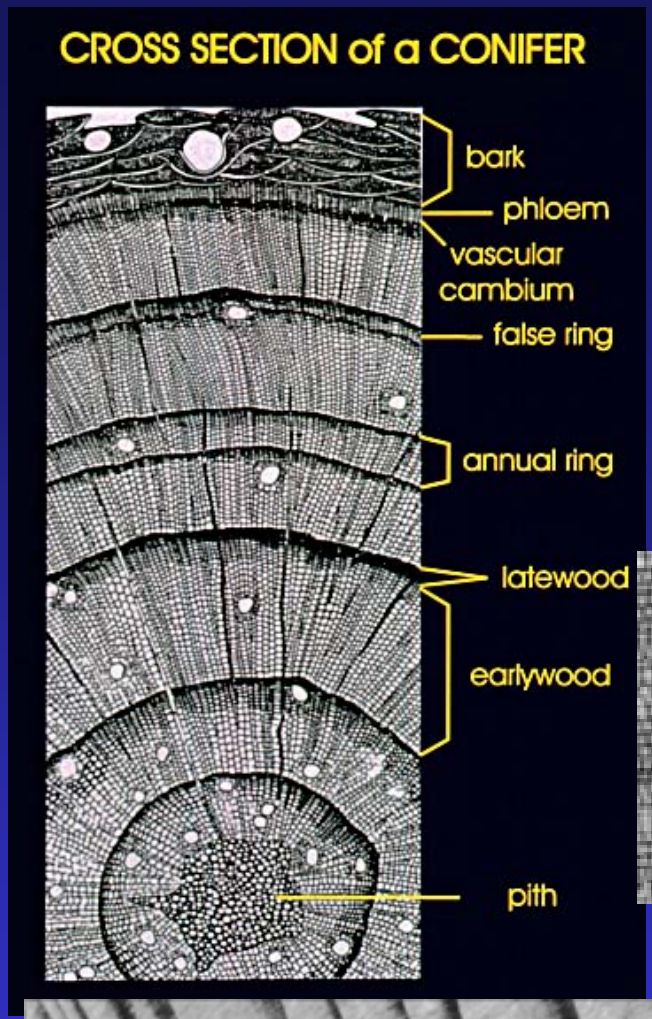
- BASICS OF "DENDROHYDROLOGY"
- COLORADO RIVER RECONSTRUCTIONS
- THE CURRENT DROUGHT IN CONTEXT

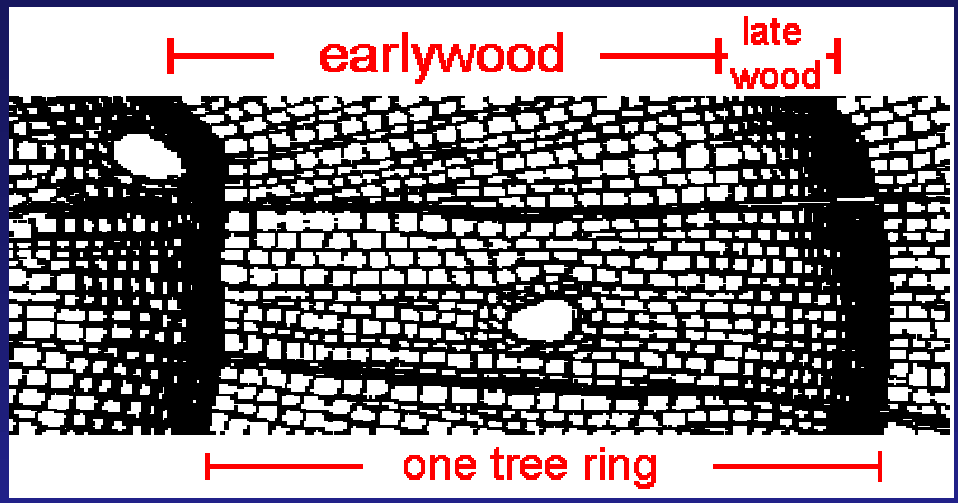
**Acknowledgments:** The Salt River Project, National Science Foundation, Katie Hirschboeck, Bob Webb

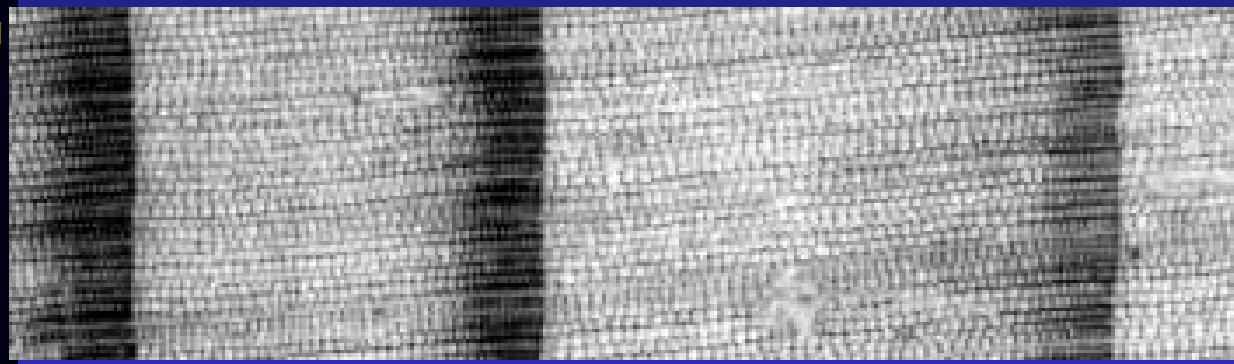
# DENDROHYDROLOGY

## RECONSTRUCTING STREAMFLOW





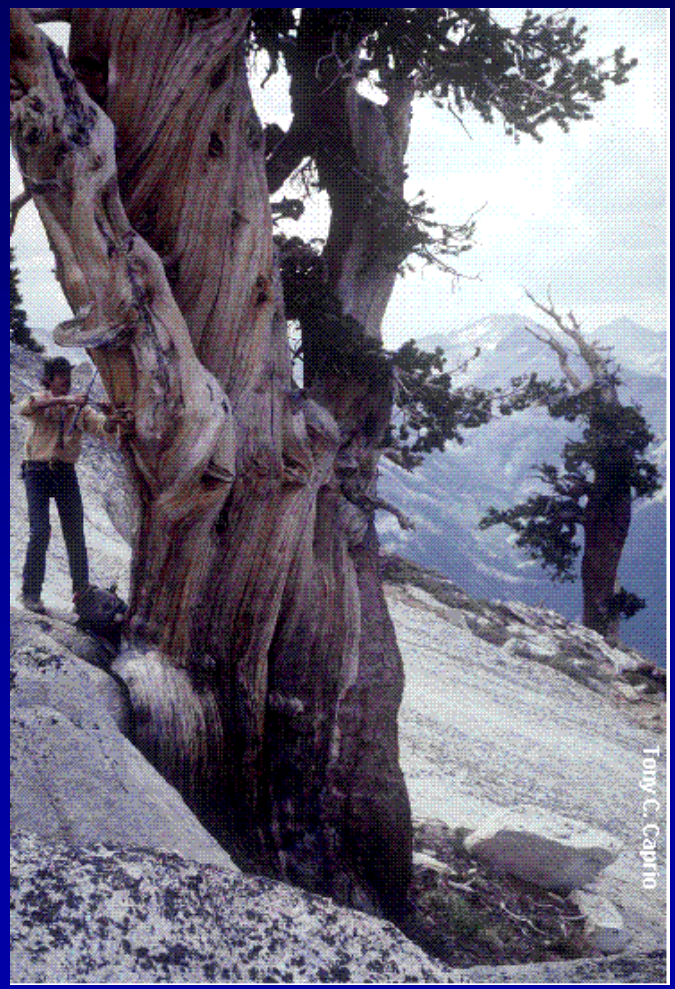



**environmentally beneficial years**

**environmentally stressful years**

# SITE SELECTION:
## Optimizing the hydrologic signal

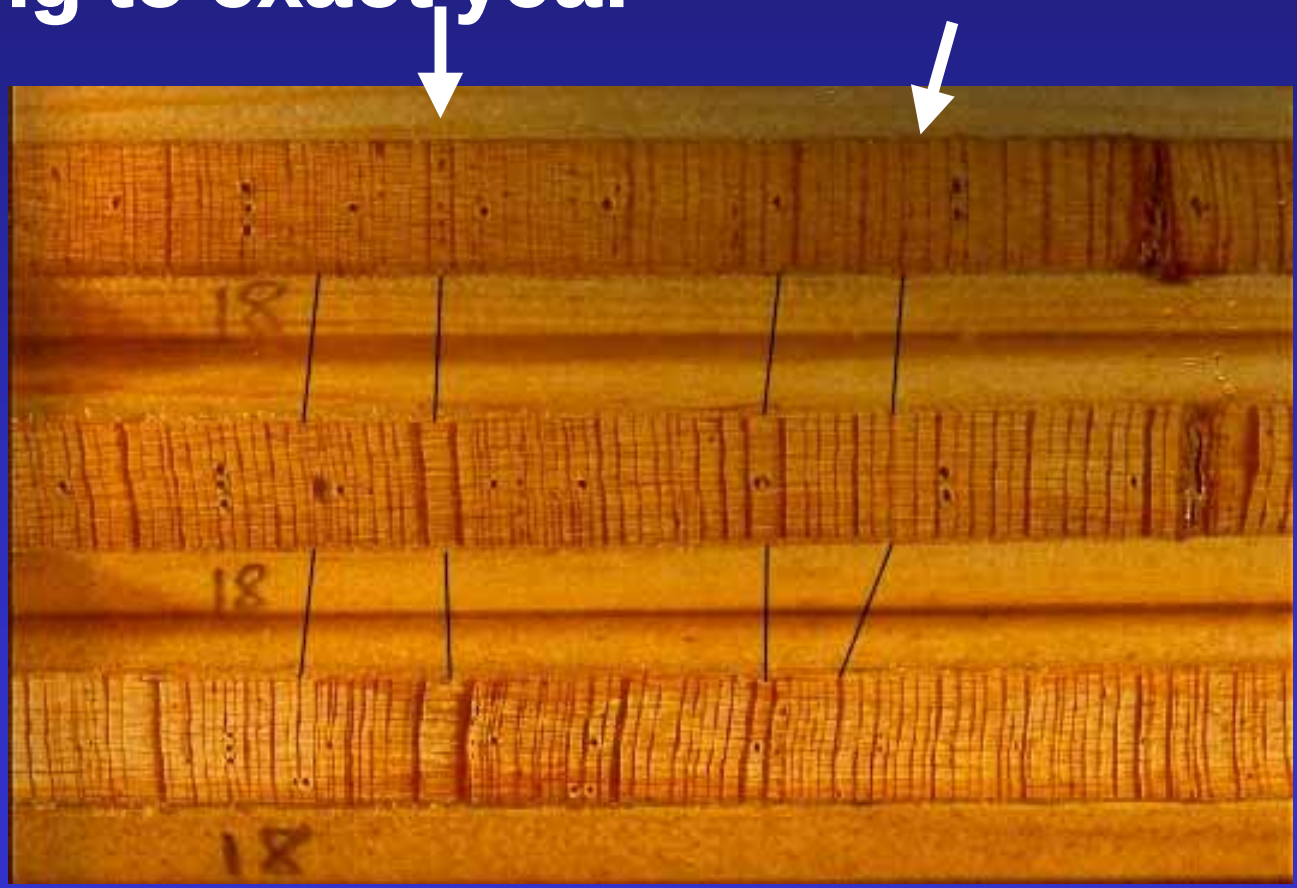



Sensitive

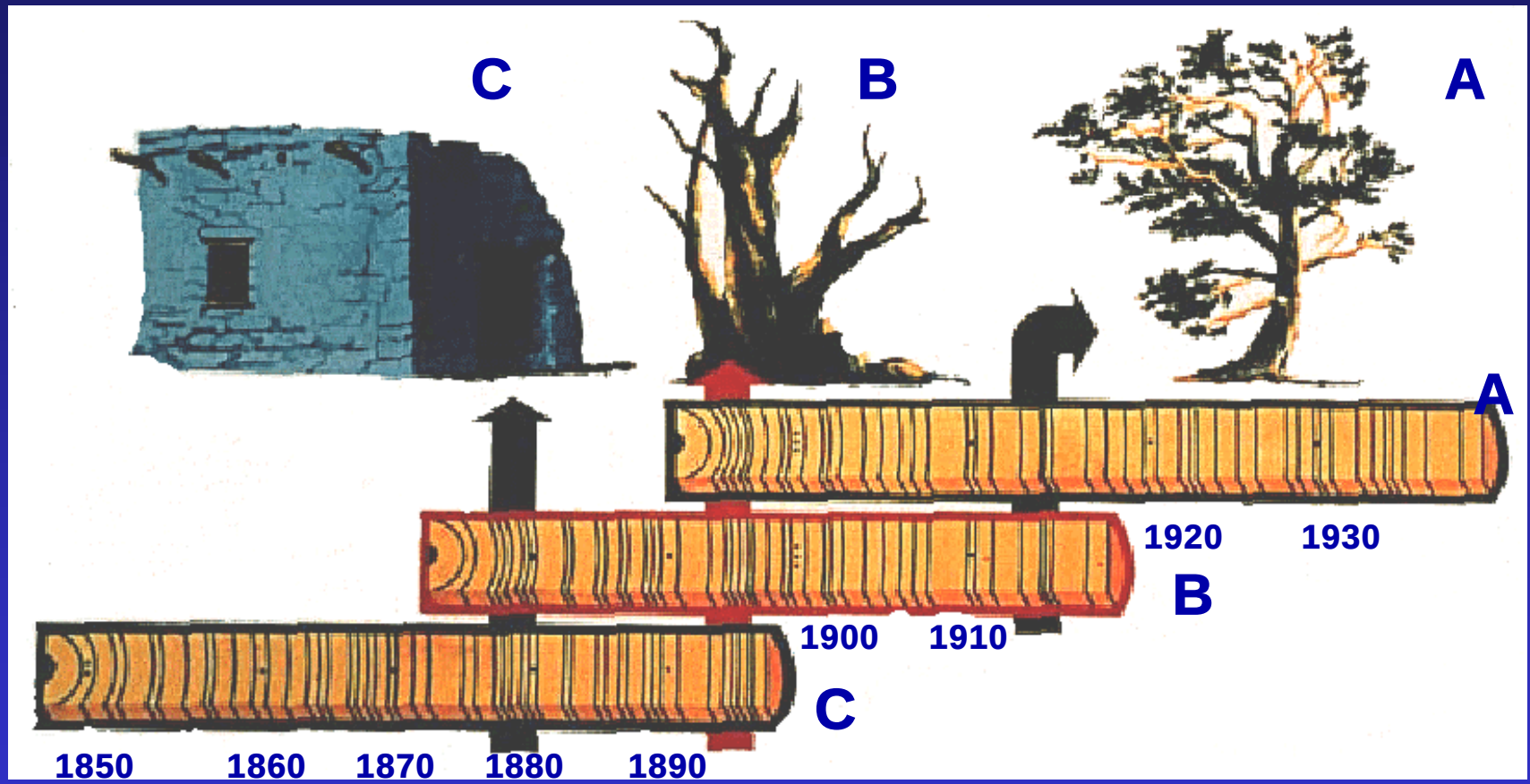
# SAMPLING:
# "Increment cores"

# CROSSDATING –

**The matching patterns in rings of several tree-ring series allow precise dating to exact year**



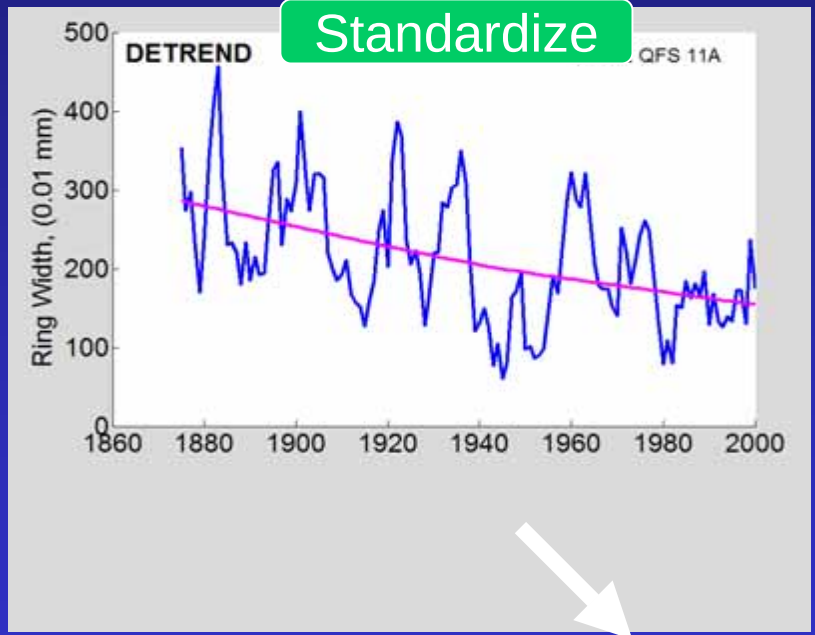
# Crossdating from living trees backward in time allows development of long chronologies



# Data Reduction

Date and Measure Rings

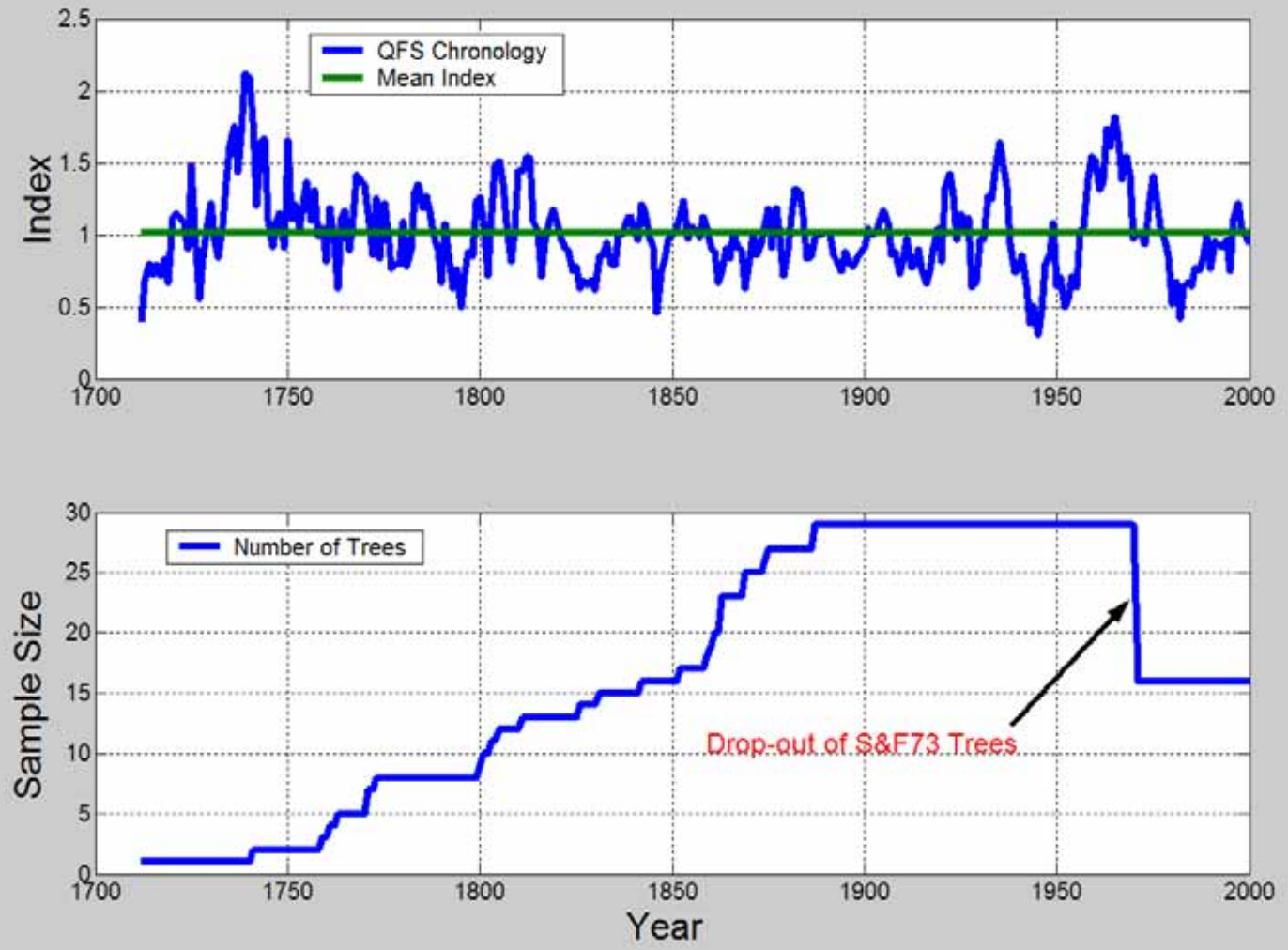
Standardize




Other Cores

Average Core Indices
Into “Site Chronology”

# Replication

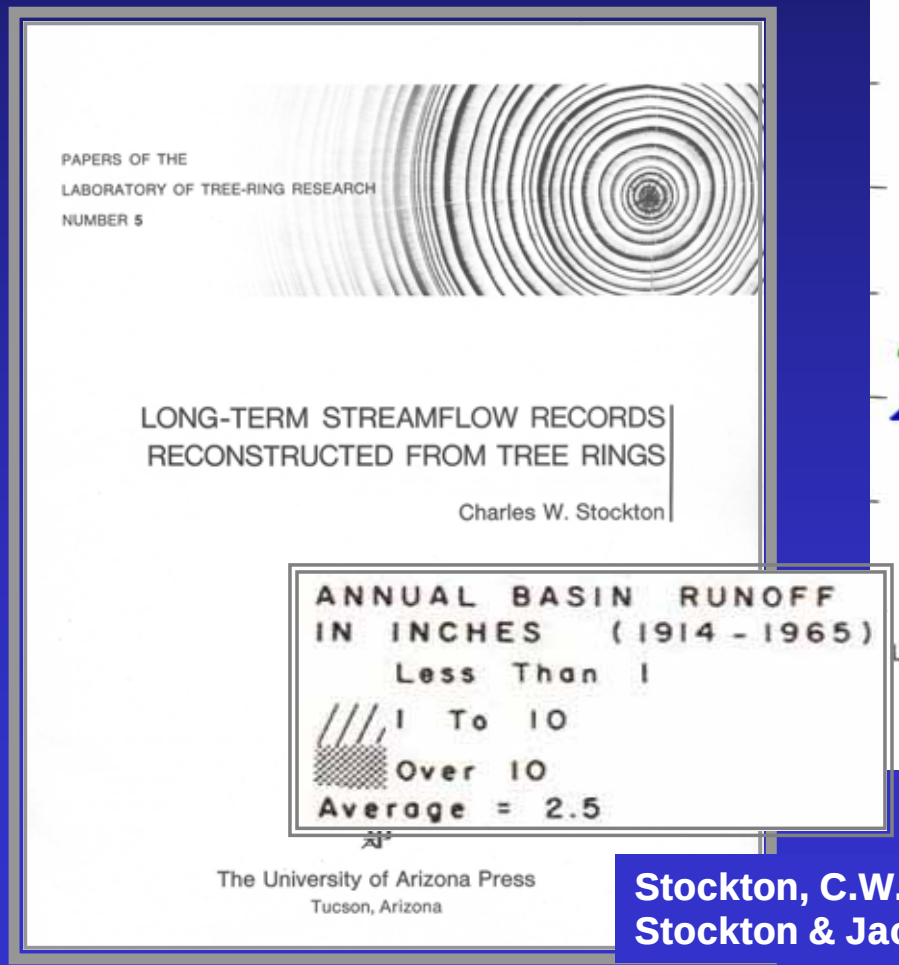


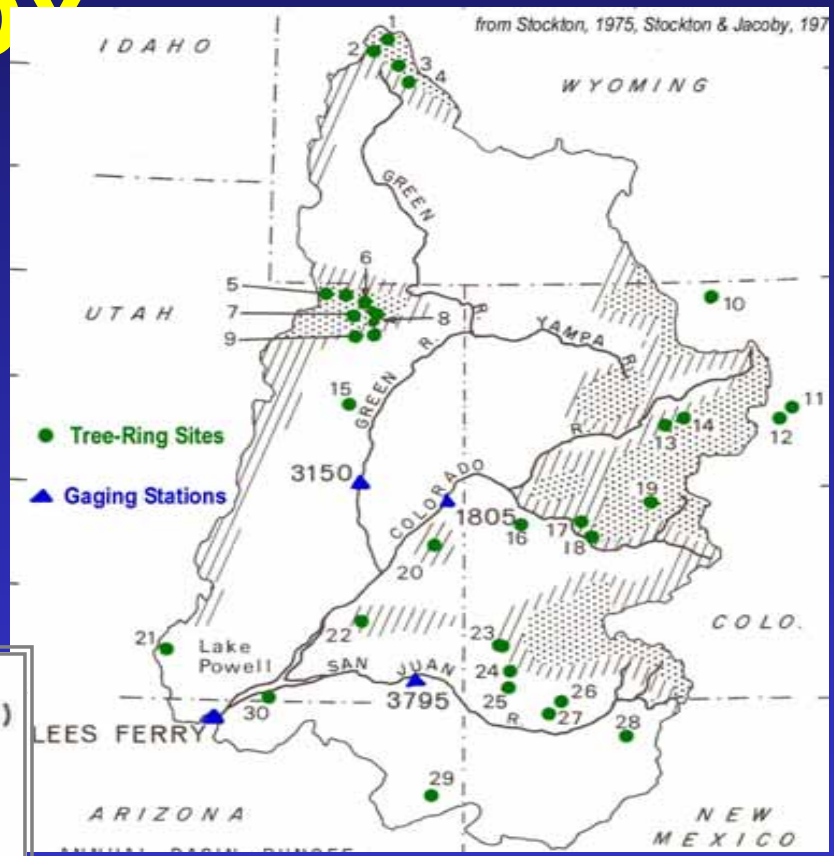
## How a Streamflow Reconstruction is Done:

- ✓ **Select locations** (gages) where streamflow will be reconstructed
- ✓ **Identify tree-ring sites** sensitive to climatic & hydrologic variability in the basin
- ✓ **Calibrate regression model(s)** based on correlation between annual runoff & ring-width indices

  *(at combinations of tree-ring sites --various methods used, not always regression)*
- ✓ **Evaluate quality of model(s)** with validation statistics;
- ✓ **Reconstruct** annual runoff back in time, with "best" model by calibration and validation statistics

# STOCKTON-JACOBY STUDY

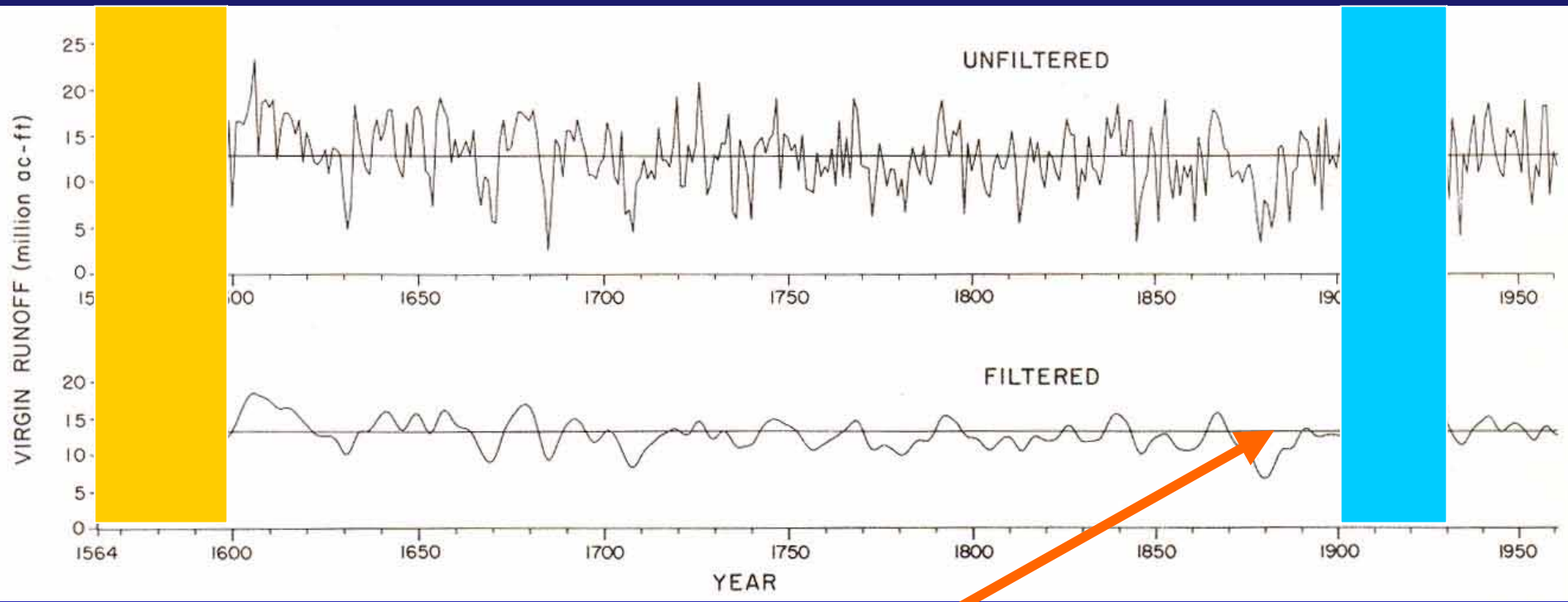



**UPPER COLORADO RIVER BASIN**

**Stockton, C.W., 1975**
**Stockton & Jacoby, 1976**

# Colorado River
## at Lees Ferry
## Reconstructed Runoff

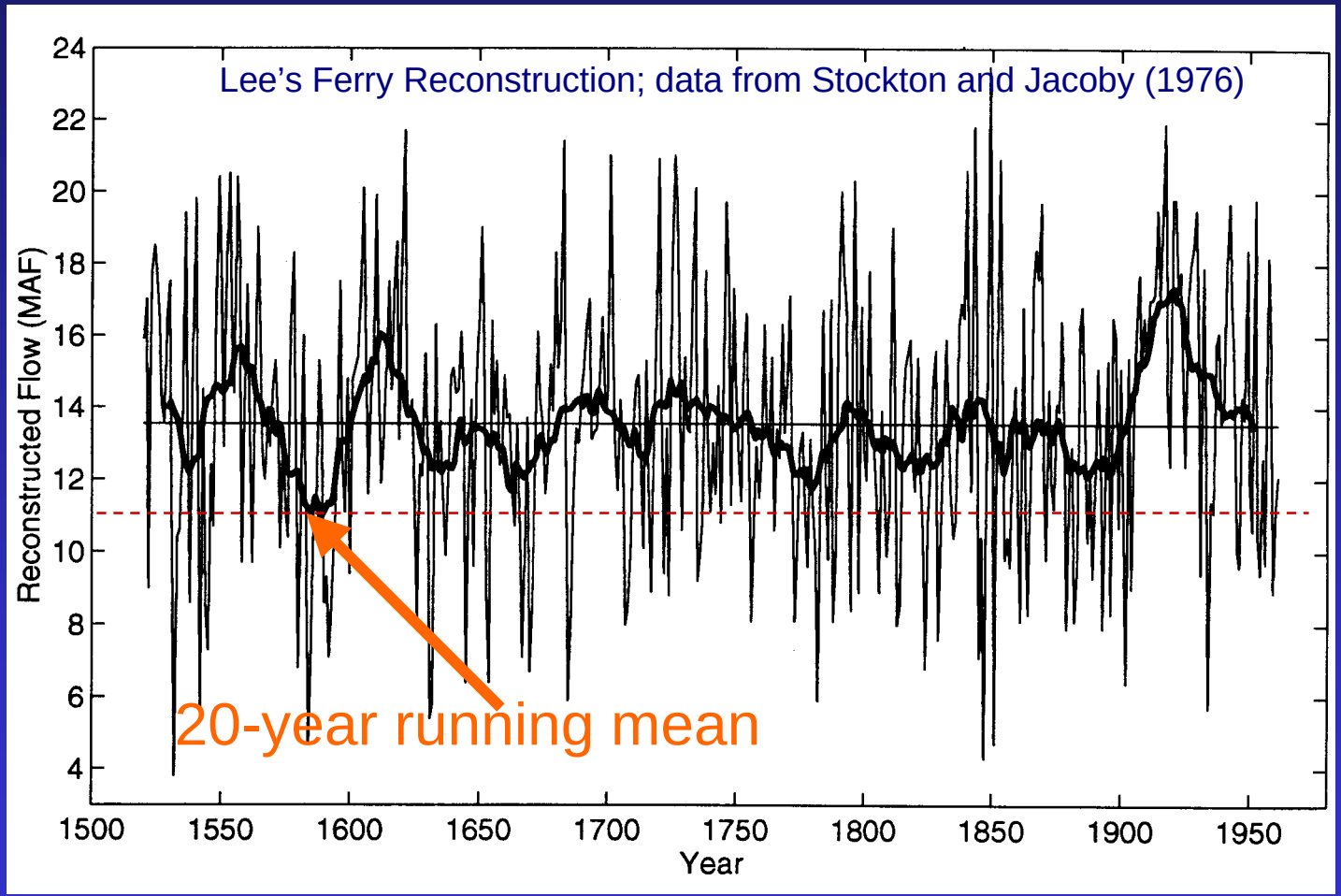



**13.5 MAF**

Stockton, 1975
Stockton & Jacoby, 1976

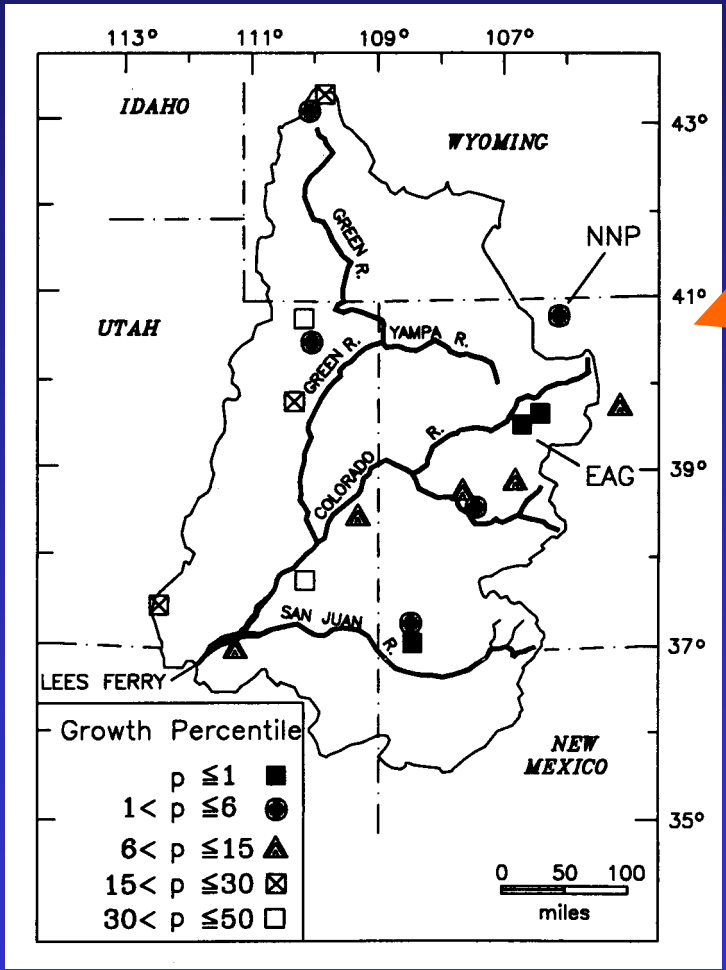
# MULTI-DECADAL DROUGHT

## SMOOTHING HIGHLIGHTS SEVERITY OF LATE 150O'S DROUGHT




**Source of figure: Meko et al. 1995, Water Res. Bulletin**

# LOW TREE-GROWTH WAS WIDESPREAD OVER THE UCRB IN 150O'S DROUGHT




**Percentile ranking of 1579-1598 tree-ring index among all 20-yr running means, 1520-1963**

Source: Meko et al. 1995, "The Tree-ring record of severe sustained Drought", *Water Res. Bull*. 31, 789-801

# HIDALGO ET AL. RECONSTRUCTION

WATER RESOURCES RESEARCH, Vol 36, NO. 11, PAGES 3241-3249, NOVEMBER 2000

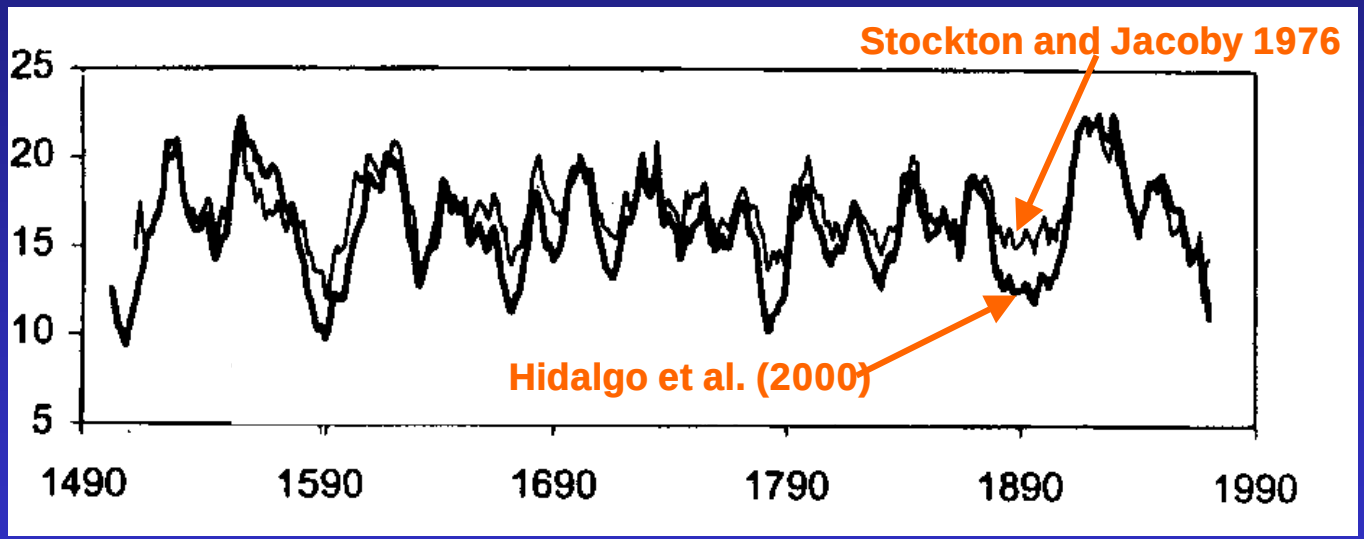
Alternative prjncipal components regression procedures
for dendrohydrologic reconstructions

Hugo G. Hidalgo
Thomas C. Piechota
John A. Dracup

**The streamflow reconstruction proposed in this study shows more intense drought periods, which may influence the future allocation of water supply in the Colorado River Basin**.

# SENSITIVITY TO MODEL CHOICE (10-YR RUNNING MEAN)

## Colorado River at Lees Ferry



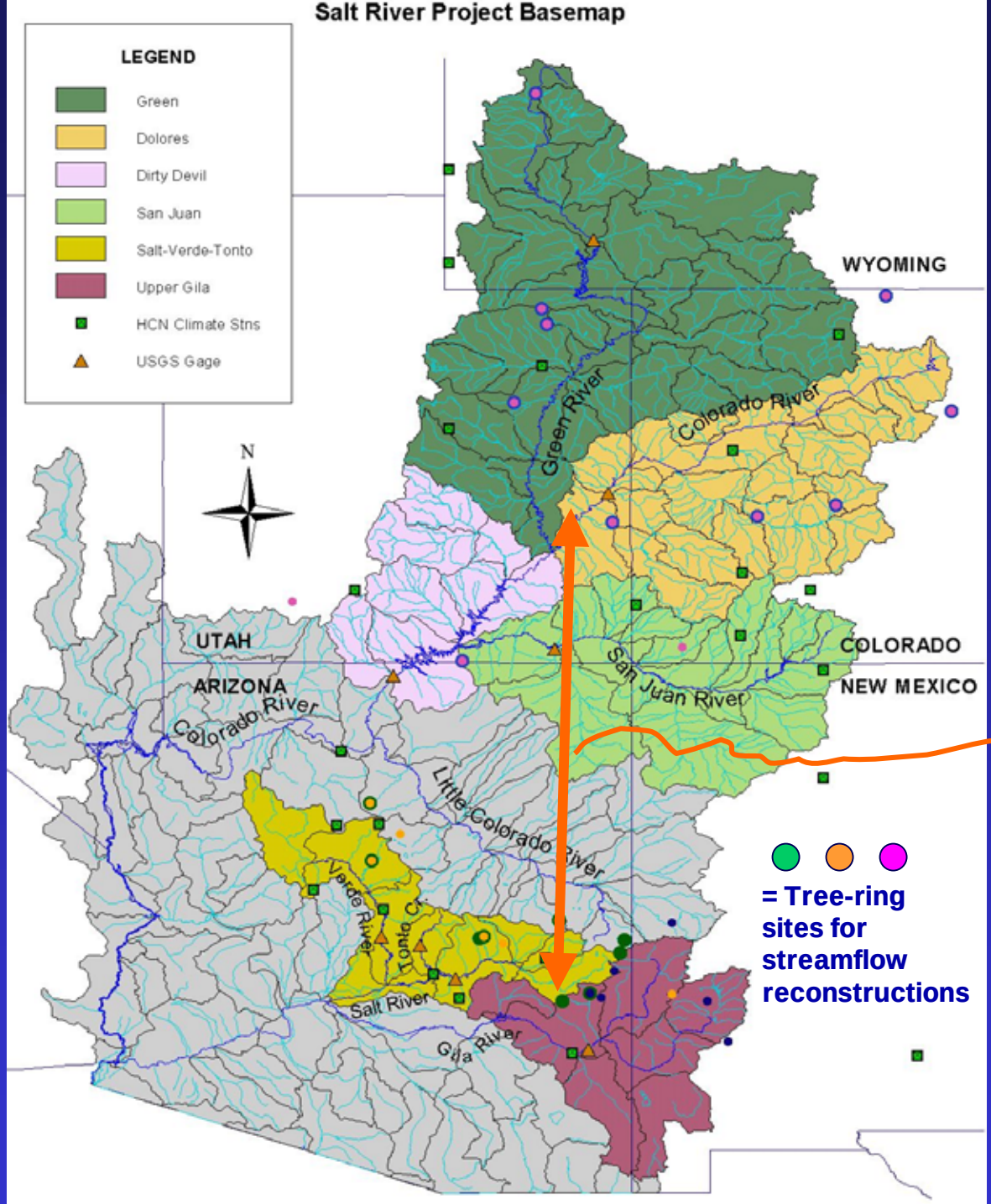

Source: Hidalgo et al. 2000

# REVISED RECONSTRUCTIONS USING AUGMENTED TREE-RING NETWORK

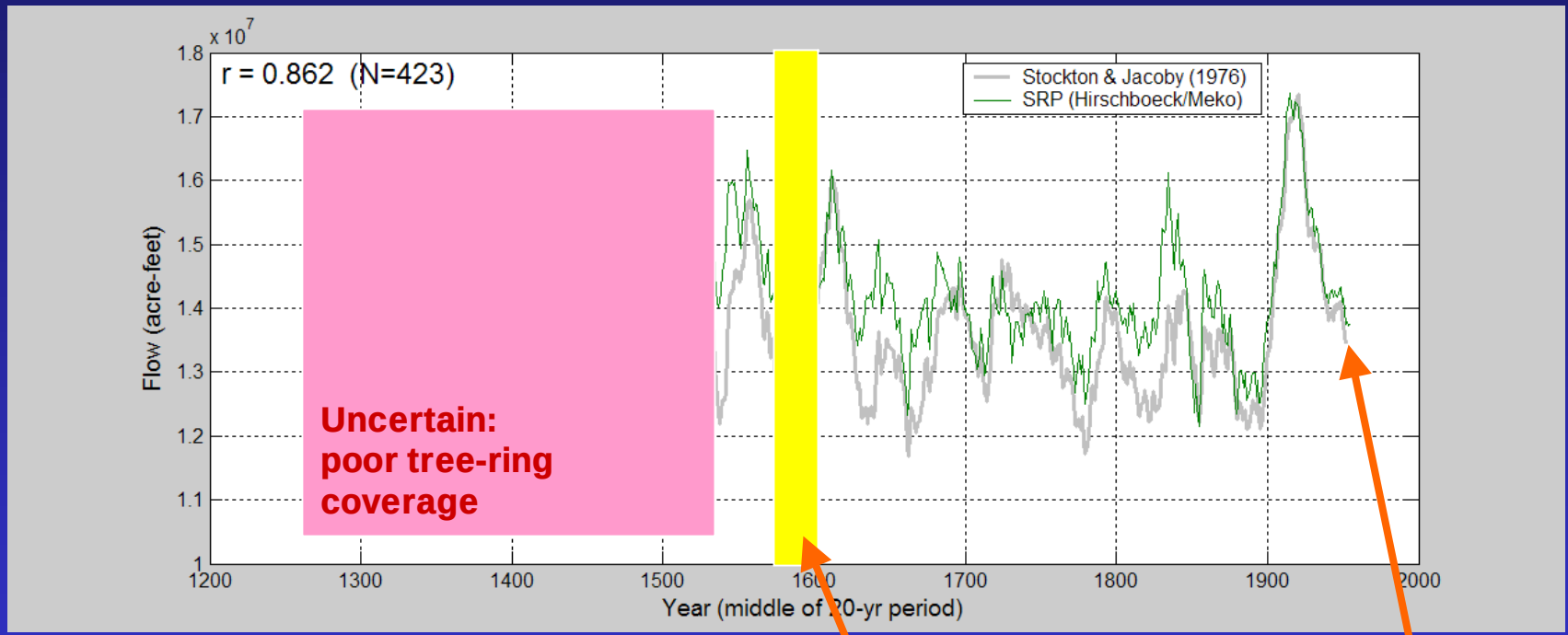
*A Collaborative Project Involving*
*The Laboratory of Tree-Ring Research (LTRR)*
*& The Salt River Project (SRP)*

**"A Tree-ring Based hydroclimatic Assessment of Synchronous Extreme Streamflow Episodes in the upper Colorado & Salt-Verde River Basins"**

**Katherine K. Hirschboeck & David M. Meko**
**Laboratory of Tree-Ring Research**
**The University of Arizona**


Salt River Project Basemap
LEGEND
Green
Dolores
Dirty Devil
San Juan
Salt-Verde-Tonto
Upper Gila
HCN Climate Stns
USGS Gage
N
WYOMING
Green River
Colorado River
UTAH
COLORADO
NEW MEXICO
ARIZONA
Colorado River
San Juan River
Little Colorado River
Verde River
Tonto Cr.
Salt River
Gila River
Joint Drought
= Tree-ring sites for streamflow reconstructions

# 1500's Drought Robust to Changes in Modeling Method and Basic Data



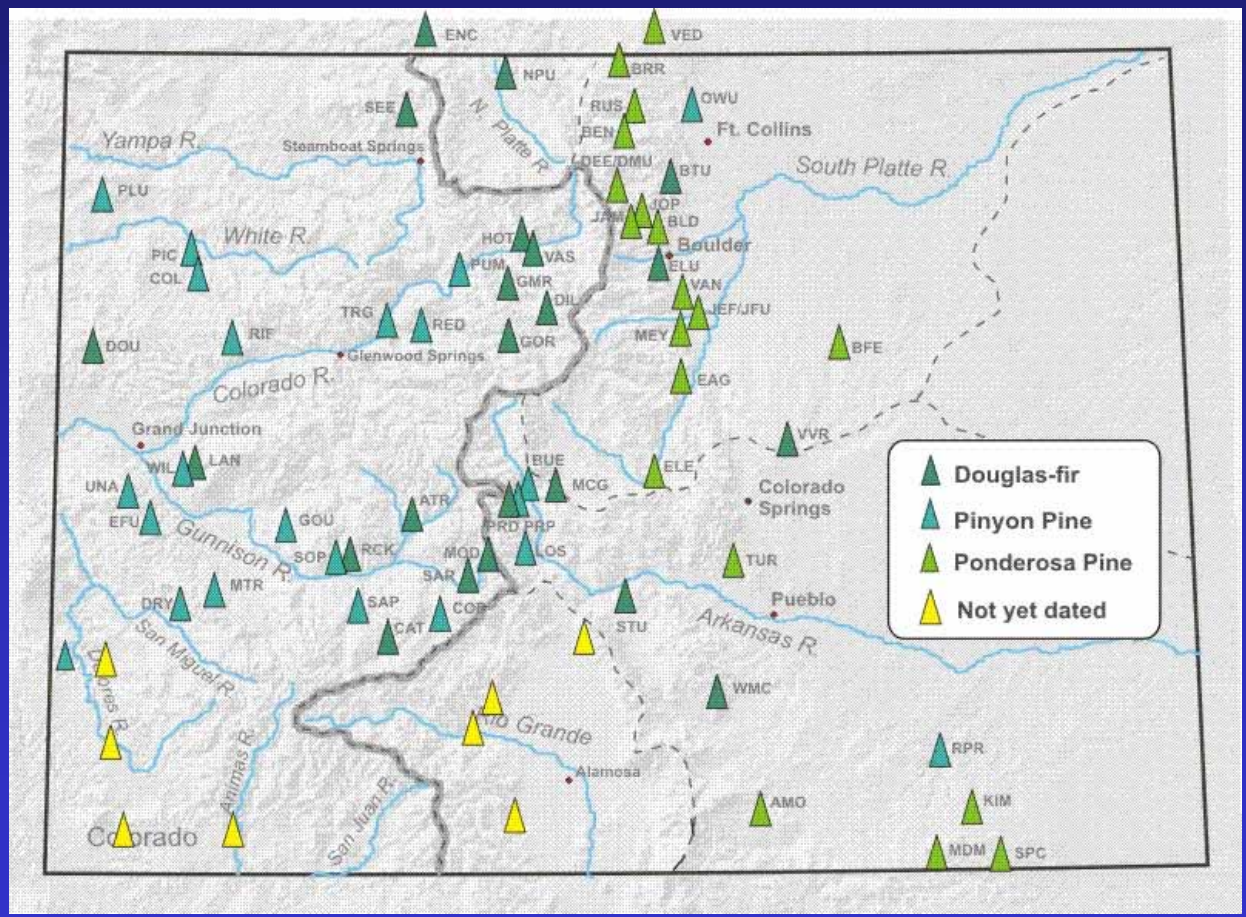

Note: SRP version preliminary

1500s drought

20-year running mean

# IMPROVING SITE COVERAGE

**Recent Colorado tree-ring collections, part of greatly updated network to be applied in new UCRB reconstructions by Connie Woodhouse and others. Expected completion winter 2004-2005.**

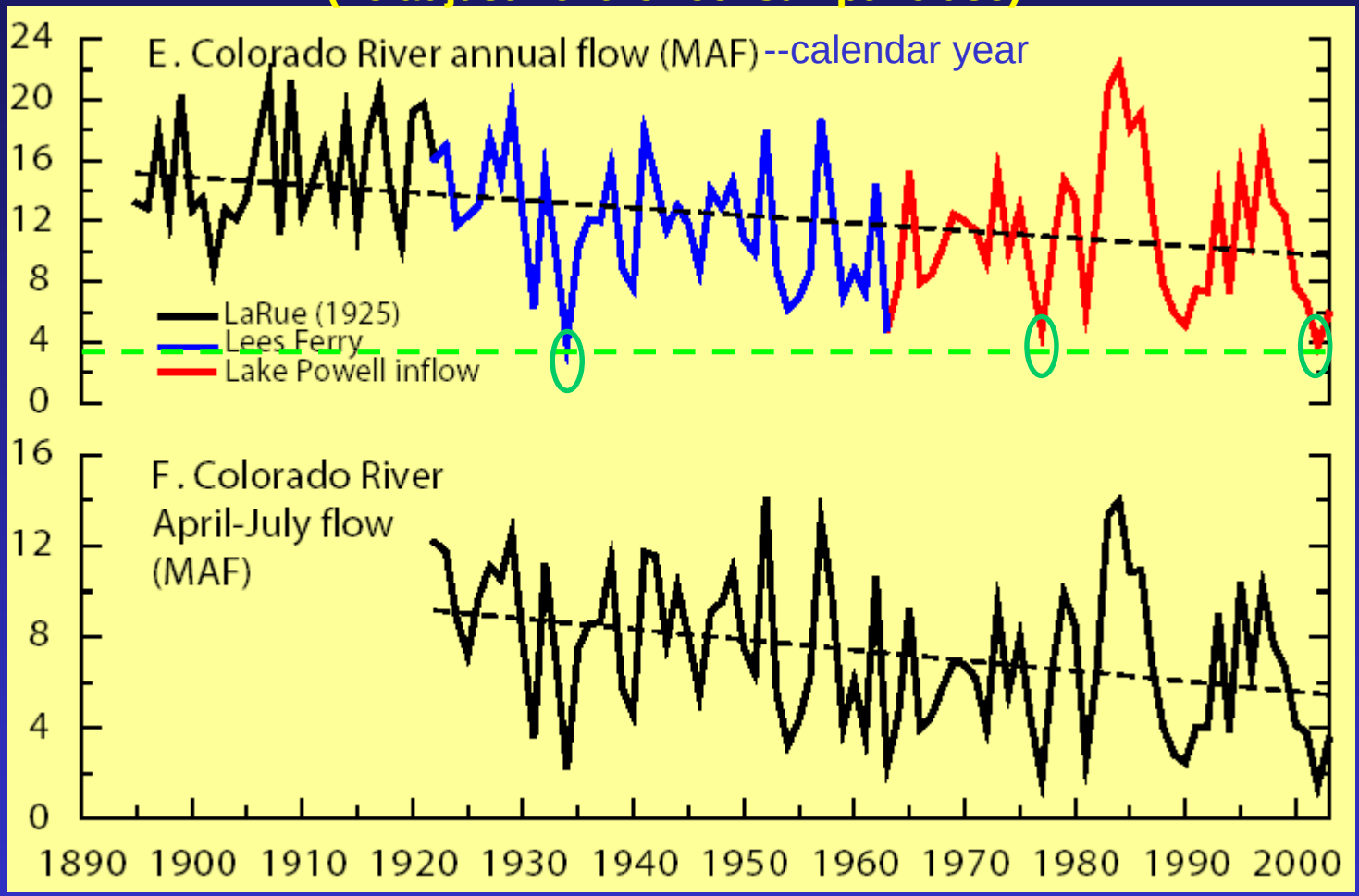



Source: Connie Woodhouse (NOAA)

# CURRENT DROUGHT IN CONTEXT

# GAGED RECORD, 1895-2003

**(no adjustment for consumptive use)**




**LOWEST:**

**2002 = 3.8 MAF**

**1934 = 3.9 MAF**

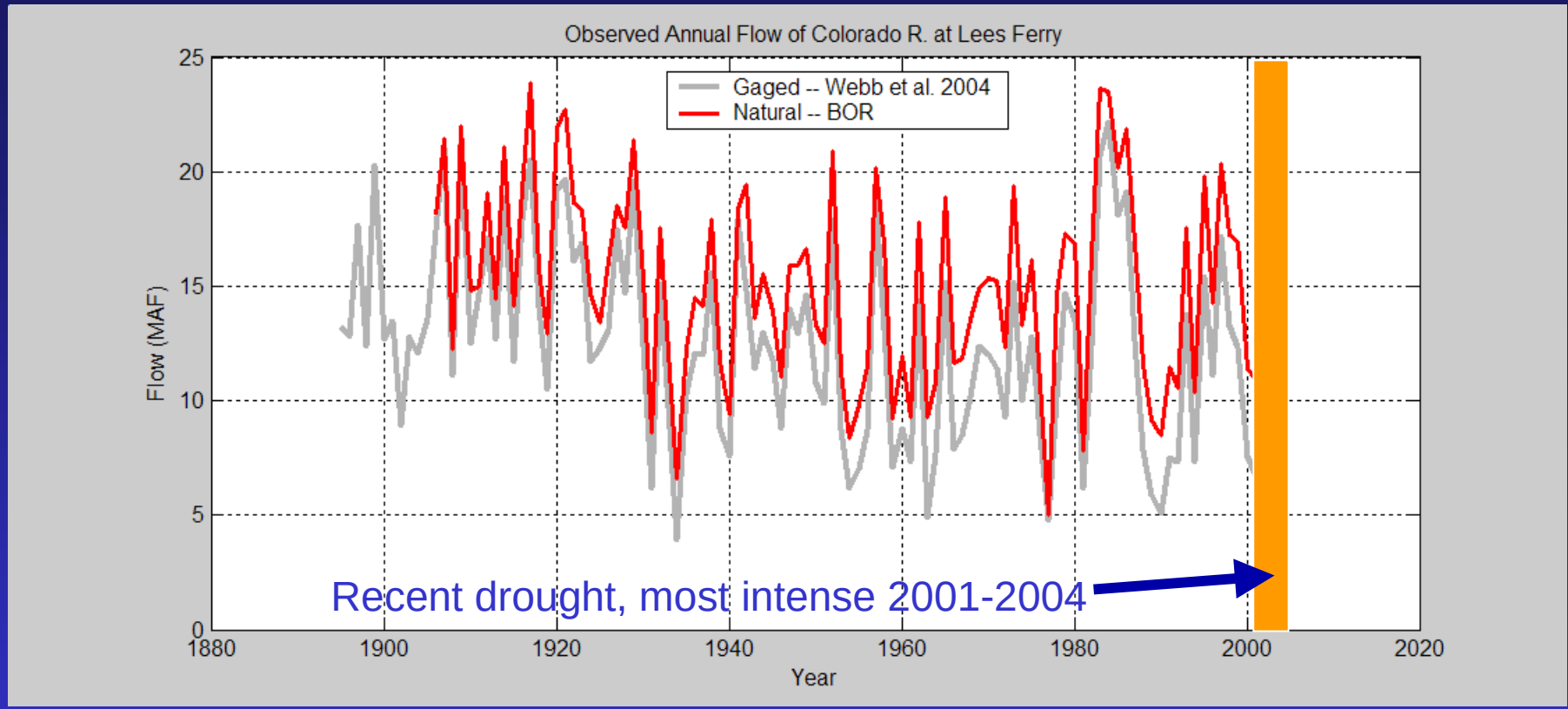
**1977 = 4.8 MAF**

Source: *Robert H. Webb, Gregory J. McCabe, Richard Hereford, and Christopher Wilkowske (in review). :* Climatic fluctuations, drought, and flow in the Colorado River. USGS Fact Sheet ?-04

**2001-2004 mean = 5.5 MAF**

**(2004 projected at 5.6 MAF)**

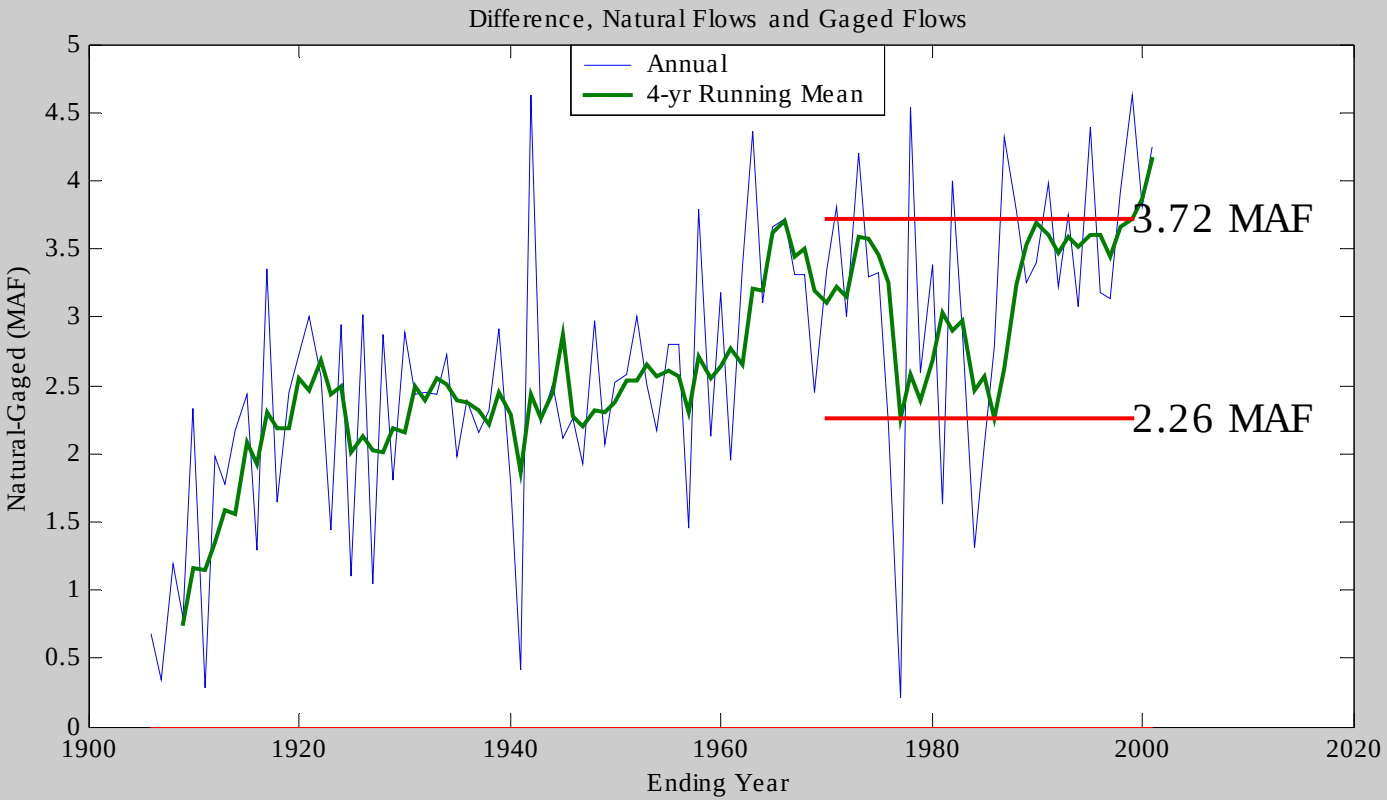
# GAGED AND NATURAL FLOWS




- Tree-ring reconstructions are of natural flow
- What is the natural flow in the “recent” drought (2001-2004)?
- Estimate by shifting the gaged flows by some amount

# DIFFERENCE, NATURAL FLOWS AND GAGED FLOWS

# (COMMON PERIOD 1906-2001*)




*Natural flows provisional after 1999

## TWO BRACKETING ESTIMATES OF 2001-2004 WATER-YEAR TOTAL NATURAL FLOW

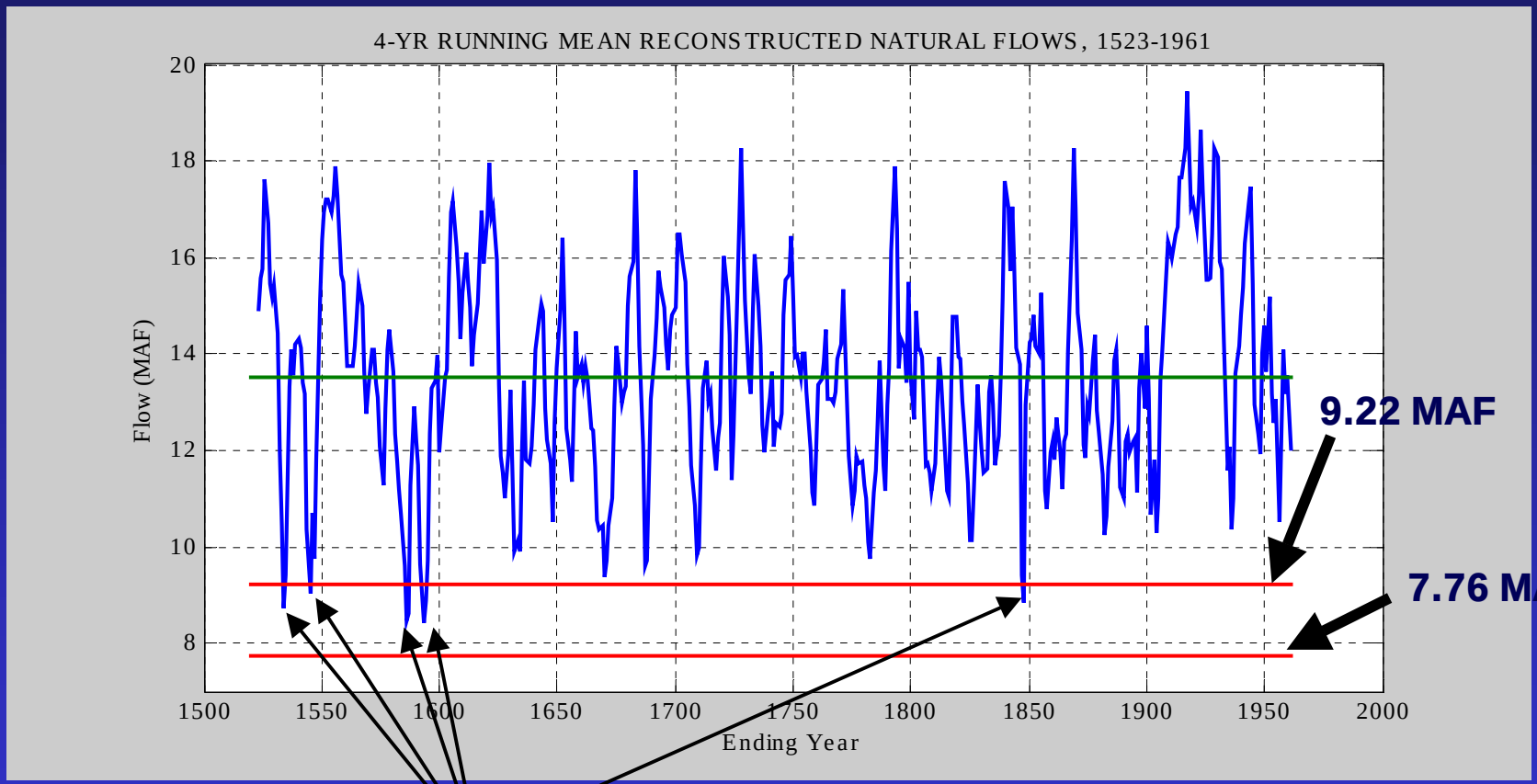
**5.5 MAF + 3.72 MAF = 9.22 MAF**

**5.5 MAF + 2.26 MAF = 7.76 MAF**

Offset, natural minus gaged flow

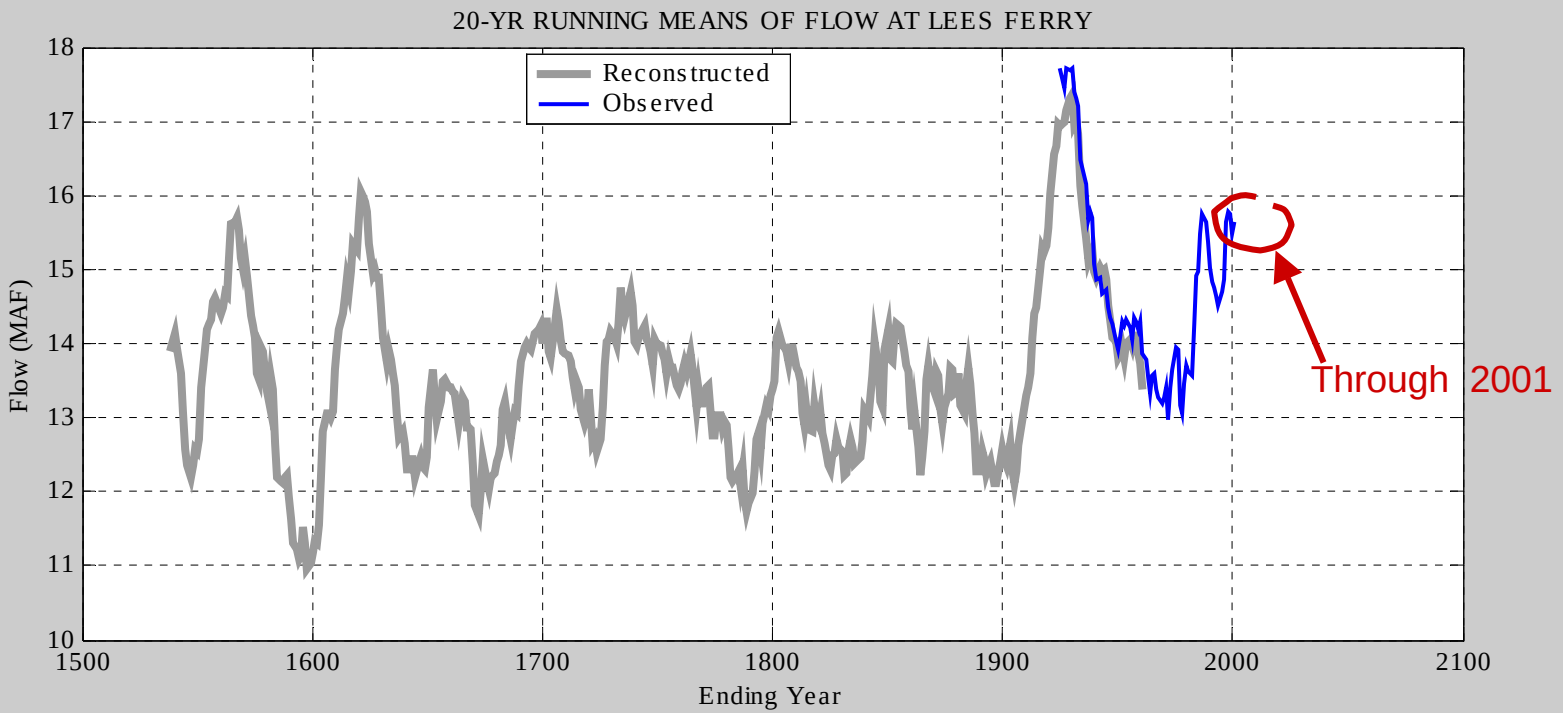
Average gaged flow, 2001-2004 (Webb et al. 2004)

# 2001-2004 IN LONG-TERM CONTEXT




Flows lower than in 2001-2004, depending on estimate of consumptive uses and diversions

# THE CURRENT DROUGHT IS NOT YET "MULTI-DECADAL"




## Lowest 20-yr running means

Reconstructed: 1579-1598: 10.95 MAF

Observed: 1953-1972: 12.98 MAF

# CONCLUSIONS

- **The last four year are arguably drier than any previous 4-year period on the Colorado River back to A.D. 1520**
- **The “epic drought” of the Colorado River was in the late 1500s. That drought had two episodes of low flows similar in magnitude to those of the current drought**
- **Tree-ring estimates of past drought severity are never “final”. Estimates vary depending on data treatment, choice of statistical reconstruction model, and coverage by the basic data.**